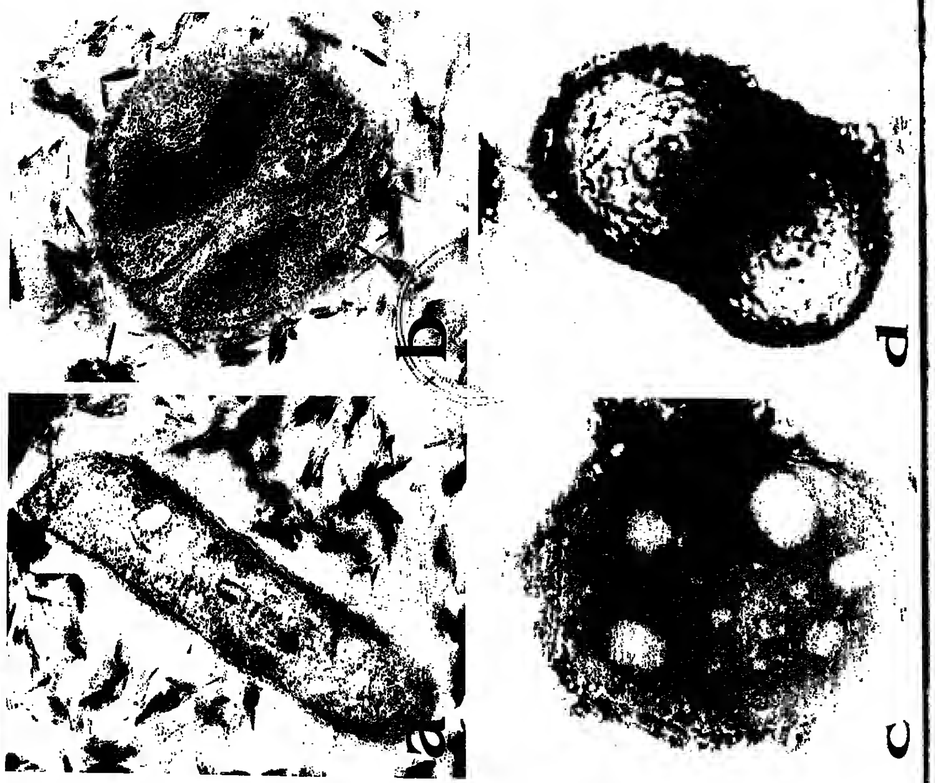
EOS
Transactions, American Geophysical Union
Vol. 64 No. 33 August 16, 1983



EOS, Transactions, American Geophysical Union Vol. 64, No. 33, Pages 505–512 August 16, 1983

Meetings (cont. from p. 511)

The Response of the Upper Ocean to Very Strong Wind Forcing (O)

This session will focus on the physical mechanisms that govern the upper ocean's response to discrete, severe storms. Papers are invited that will illuminate these mechanisms with recent results (and opinions) based on observation, theory, or numerical models. Of particular interest is the question of how large the current gradient will be in a uniform mixed layer in response to large wind stresses. Other topics of interest include mixed layer dynamics and effects of topography and dissipation. For more information contact session chairman R. L. Gordon, Exxon Production Research Company, P.O. Box 2189, Houston, TX 77001. In addition, send the original and two copies of the abstract by September 14 to AGU Fall Meeting, 2000 Florida Avenue, N.W., Washington, DC 20009.

Deep Fault Zone Drilling (T)

See description at the beginning of the Meetings section of this issue of *Eos*.

Exhibits

The exhibits will be located on the mezzanine, Cathedral Hill Hotel, Monday, December 5, through Thursday, December 8, 9:30 A.M. to 4:00 P.M.
Exhibitors confirmed to date are

Academic Press, Inc.
American Geophysical Union
EG&G Geometrics
Elsevier Science Publishing Co.
Defense Mapping Agency/HTC
Handar
Kinemetrics
Qualimetrics, Inc.— WEATHERtronics
Schmidt Instrument Co.
Sprengnether Instruments
Springer-Verlag, New York
Teledyne Geotech

Social Events

An icebreaker party on Monday evening at the Cathedral Hill Hotel will be the opening social event of the meeting. There will be an awards ceremony on Thursday evening from 5:45 to 6:30 P.M. in the Crystal Ballroom of the Holiday Inn Golden Gateway. All meeting participants are invited to attend. At a wine-tasting reception following the ceremony you can share a glass of wine with your colleagues.
Complimentary refreshments will be served daily at both hotels 9:30–10:30 A.M. and 2:45–3:45 P.M.

Business Meetings and Section Luncheons/Dinner

The AGU Council will meet Tuesday, December 6, at 5:30 P.M.
The section lunches and dinner will be held at the following restaurants: Nikko, at Van Ness and Pine; Casa de Cristal, 1122 Post Street; A. Sabella's, an Fisherman's Wharf; and the Holiday Inn Golden Gateway.

Planetology/Volcanology, Geochemistry and Petrology

Tuesday, December 6, 12 P.M., Casa de Cristal, $9.

Seismology/Tectonophysics

Tuesday, December 6, 12 P.M., Nikko, $5.

Geomagnetism and Paleomagnetism

Wednesday, December 7, 12 P.M., Casa de Cristal, $5.

Hydrology

Wednesday, December 7, 12 P.M., Holiday Inn Golden Gateway, $9.

Solar-Planetary Relationships

Wednesday, December 7, 6 P.M., A. Sabella's, $20.

Atmospheric Sciences

Thursday, December 8, 12 P.M., Nikko, $9.

Geodesy

Thursday, December 8, 12 P.M., Holiday Inn Golden Gateway, $9.

Field Trip

On Sunday, December 4, 9 A.M. to 5 P.M., in connection with the Nano-Plate-Tectonic Symposium, there will be a field trip to the Franciscan nano-terranes in San Francisco, stressing their contact relations. The trip will be led by Clark Blake and Clyde Wahrhaftig.
The $25 per person cost includes tour bus, lunch, and field trip guide.
The trip will leave from and return to the Cathedral Hill Hotel.
The trip will be limited to 40 persons, and space will be reserved for the first 40 to sign up. Others can be put on a waiting list, or their checks can be returned, as they wish.
Those interested should send the form printed in this issue with a check made out to C. Blake, Jr., addressed as indicated on the form. Be sure to mark on outside of the envelope "For AGU Dec. Field Trip."

Krakatau 1883: A Classic Geophysical Event

Tom Simkin and Richard S. Fiske
National Museum of Natural History, Smithsonian Institution, Washington, DC 20560

This week marks the 100th anniversary of Krakatau's 1883 eruption, perhaps the most famous volcanic event in recorded history. During a 23-hour period on August 26 and 27, 1883, more than 18 km³ of volcanic debris thundered upward from Krakatau, resulting in the death of more than 36,000 people and causing widespread devastation to the surrounding area. Moreover, the 1883 events at Krakatau caused geophysical phenomena that were observed around the world, making it (at least up until Mount St. Helens' 1980 eruption) the household word for a classic volcanic catastrophe.

One hundred years ago, Krakatau was a 5 × 9 km island in the Sunda Straits, between Java and Sumatra in the Dutch East Indies. It was a familiar landmark, both to the tens of thousands of men by coastal residents and to the crews of thousands of ships from Europe and the Americas that passed through the Straits each year on their way to and from the far east. The volcano had last erupted in 1681 and was not regarded as a likely site for renewed and catastrophic activity.

Several large earthquakes were felt in the Sunda Straits area in the early 1880's. More occurred on May 9 and 10, 1883, initiating a 5-day swarm of felt earthquakes that led directly to the outbreak of the initial activity on May 20, when ash and steam boiled upward from the volcano, producing a spectacular sight. One hundred years ago, before the advent of telephones and television, people paid more attention to the written word, and many recorded their observations in marvelously expressive prose that somehow makes the event come alive again. For example, the chaplain of the German warship *Elisabeth* described the initial eruption as follows (translation from the German by H.-U. Schmincke):

> There, at least 17 nautical miles distant, an enormous, shining, wide, vapor column rose extremely rapidly to half the horizon, and reached within a very short time the colossal height of at least 11,000 meters . . . the sky darkened continuously until a homogeneous, gray cloud covered the entire horizon. We should not remain in doubt for long about the nature of these clouds. The fresh wind came from the sea and not from land, and brought along very fine ash rain, which laid a light-gray, slightly yellowish, extremely fine, pulverized mass on the entire ship. . . . On the next morning, May 21, the ship, which was so clean 24 hours ago, looked very strange: It looked like a mill ship or, more precisely, like a floating cement factory.

On May 27, the steamship *London* visited Krakatau to obtain a closeup view of the ongoing eruption, and amongst its fascinated passengers was a photographer named Hamburg. He apparently took several photographs of the scene, because in succeeding years a number of published accounts of the Krakatau eruption (including the famous 1888 report by the Royal Society of London) contained lithographs and other artistic renditions that were said to have been derived "from a photograph taken on Sunday, May 27, 1883."

To our knowledge, the most famous of these photographs remained lost and was never published—that is, until a Smithsonian colleague surprisingly discovered that the grandson of R. Bréon (leader of the French expedition to Krakatau in 1884) currently lives in Paris and that, safeguarded in his family album, were the missing Hamburg photographs of the erupting volcano. One of these photographs is reproduced on the cover of this issue of *Eos*.

After the *London*'s visit on May 27, interest in the eruption seemed to wane. The eruption in fact continued with considerable vigor, but few details were recorded, and it is said that visitors to Batavia (now Djakarta) might have failed to hear of its existence at all. The last person to set foot on the island was a topographic engineer named Ferzenaar. He carried out a partial survey of the island in early August 1883 (Figure 1) but, noting the continuing activity, counseled that a more complete "survey of the island itself is inadvisable."

Two weeks later, on August 26, the paroxysmal eruption began and continued with extraordinary intensity until about noon on August 27. The details of this activity are not known, but at least 18 km³ of juvenile dacitic ejecta were erupted. Most of the island of Rakata collapsed to form a caldera, about 7 km in diameter, whose floor lay submerged beneath the waters of the Sunda Straits. The collapse took place in less than two days and with remarkably few reported earthquakes. The post-paroxysmal configuration of Krakatau was recorded by R. D. M. Verbeek just 7 weeks after the eruption; it can be seen in Figure 2.

The culminating eruption, at 10 A.M. on August 27, produced huge volumes of airborne tephra that completely blocked out the sun and brought darkness to the Sunda Strait until the next morning. The same event produced the largest of many huge tsunami that spread out through Krakatau and crashed onto the nearby coasts of Java and Sumatra. Waves cresting at heights up to 40 m swept inland for several kilometers, destroying virtually everything in their path. As the waters receded, immense tangles of vegetation, remains of towns and villages, and tens of thousands of drowned people were carried back on the sea, where they, in addition to huge volumes of floating pumice, choked parts of the Sunda Strait for months.

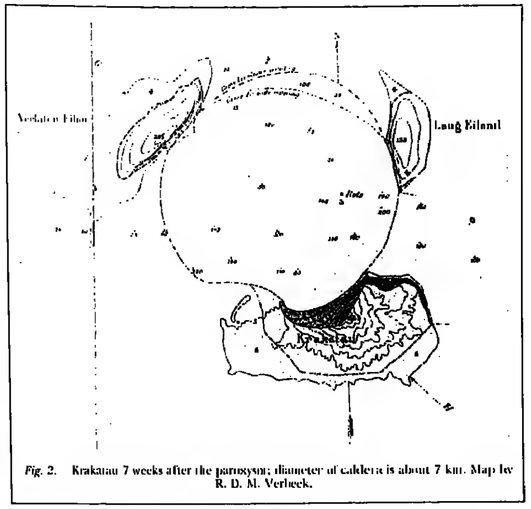


Fig. 2. Krakatau 7 weeks after the paroxysm; diameter of caldera is about 7 km. Map by R. D. M. Verbeek.

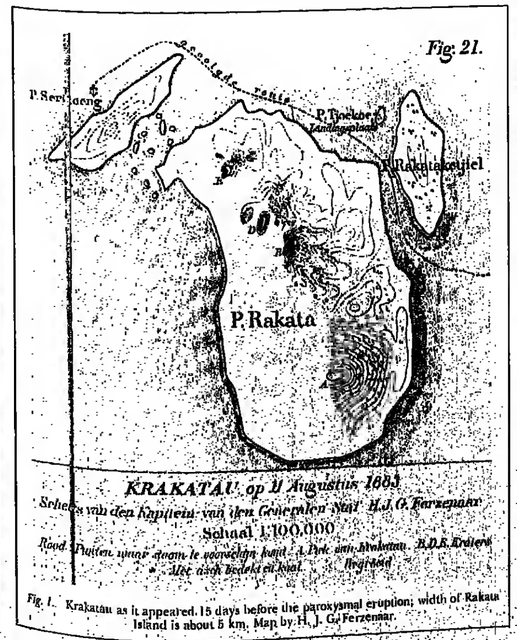


Fig. 1. Krakatau as it appeared 15 days before the paroxysmal eruption; width of Rakata Island is about 5 km. Map by H. J. G. Ferzenaar.

There were understandably few first-hand accounts of the effects of the tsunami, but one, from an old Dutch pilot living in the Javanese town of Anjer, is particularly graphic:

> At first sight, it seemed like a low range of hills rising out of the water, but I knew there was nothing of the kind in that part of the Sunda Strait. A second glance—and a very hurried one it was—convinced me that it was a lofty ridge of water many feet high. . . . There was no time to give any warning, and so I turned and ran for my life. My running days have long gone by, but you may be sure that I did my best. In a few minutes, I heard the water with a loud roar break upon the shore. Everything was engulfed. Another glance around showed the houses being swept away and the trees thrown down on every side. Breathless and exhausted I still pressed on. . . . A few yards more brought me to some rising ground, and here the current of water overtook me. I gave up all for lost. . . . I was soon taken off my feet and borne inland by the force of the resistless mass. I remember nothing more until a violent blow revived me. . . . I found myself clinging to a coconut palm. Most of the trees near the town were uprooted and thrown down for miles, but this one fortunately had escaped and myself with it. . . . As I clung to the palm-tree, wet and exhausted, there floated past the dead bodies of many a friend and neighbour. Only a mere handful of the population escaped.

First-hand accounts of other survivors give convincing evidence that several thousand people on the eastern tip of Sumatra, more than 40 km northeast of Krakatau, were killed by the thermal effects of the eruption rather than by the tsunami. The hair-raising account of Mrs. Beyerinck, the wife of the Dutch Controller in the region, clearly attests to swirling clouds of hot tephra that swept several kilometers inland from the Sumatra coast. The setting for this portion of her account is a small, mountainside cabin where she and her family had taken refuge during the ongoing pandemonium (from *Krakatau*, by R. Furneaux, copyright 1964 by Prentice-Hall, Inc.):

> Someone burst in shouting "shut the doors, shut the doors." Suddenly it was pitch dark. The last thing I saw was the ash being pushed up through the cracks in the floor-boards, like a fountain. . . . I felt a heavy pressure, throwing me on the ground. Then it seemed as if all the air was being sucked away and I could not breathe. . . . [When I went outside,] I realised the ash was hot, and I tried to protect my face with my hands. The hot bite of the pumice pricked like needles. Then something got hooked into my finger and hurt. . . . I noticed for the first time that the skin was hanging off everywhere, thick and moist from the ash stuck to it. Thinking it must be dirty, I wanted to pull bits of skin off, but that was still more painful. My tired brain could not make out what it was. I did not know I had been burned.

The vivid account of Mrs. Beyerinck clearly indicates that turbulent clouds of hot tephra somehow travelled over 40 km off the Sunda Straits to the coastal areas of eastern Sumatra. There are numerous reports from nearby ships that the blanket of floating pumice north of Krakatau was so thick and coherent that parts of the Straits were temporarily transformed to "dry land." Thus, it seems possible that pyroclastic flows and surges, ordinarily unable to traverse 40 km of open water, were aided by what amounted to a temporary land bridge of floating pumice connecting Krakatau with eastern Sumatra.

Although a government steamship was carried 2.5 km inland and stranded by the tsunami, most ships safely rode out the events of August 27, and surviving crewmen provided excellent accounts. The *London*, anchored 75 km to the north, watched an early tsunami destroy the port of Telok Betung. "the best comparison is a sudden change of scenery, which in fairy tales occurs by a fairy's magic wand, but on a colossal scale and with the conviction knowledge that it is reality, and that thousands of people have perished in an indivisible moment." Later—during the darkness, ashfall, and hurricane winds of the culminating explosions—crew members noticed large barometric fluctuations. "The compass showed the strangest deviations," and "hence sea currents were observed in diverging directions." St. Elmo's fire and other electrical effects were widely reported at sea.

On the *London*, "lightning hit the mast up in seven times, moving first along the lightning rod and then jumping over to the wires with a demoniacal snapping noise. At such a moment, everything was suddenly clearly lit, showing how everything had been tinted ash gray by the mud rain, making one impulsively think of a ghost ship." At times "this mud rain was so heavy that in the space of ten minutes the mud has built a foot deep," and 160 soldiers (passengers on the ship "worked with the energy of despair at their task of clearing the decks, in spite of the twofold danger of being burnt and stunned by the hot falling stones."

The gigantic explosions, heard 4653 km away and widely mistaken for the gunfire of a nearby ship in distress, ended early on August 28. Volcanic ash was carried far from Krakatau and continued to fall on Cocos Is-

Article (cont. on p. 514)

Tom Simkin *(left), curator of petrology and volcanology at the Smithsonian Institution's National Museum of Natural History, received the B.S. degree in civil engineering from Swarthmore College in 1955 and the Ph.D. degree in geology from Princeton University in 1965. In addition to global volcanism, his research interests include the active volcanoes of the Galápagos Islands and the ancient volcanos of the Isle of Skye, Scotland.*
Richard S. Fiske, *director of the Smithsonian Institution's National Museum of Natural History, received the B.S.E. degree in geological engineering from Princeton University in 1954 and the Ph.D. degree in geology from Johns Hopkins University in 1960. Currently he is studying active volcanos in the eastern Caribbean and ancient volcanos in the Sierra Nevada.*
The parallels in their careers extend back to the time the two authors played lacrosse against each other (unknowingly) in 1954 and toiled (separately) on ships of the U.S. Coast and Geodetic Survey.

This article is based on the authors' forthcoming book entitled Krakatau 1883: The Volcanic Eruption and Its Effects, *to be published this fall by Smithsonian Institution Press, Washington, D.C.*

Article *(cont. from p. 513)*

land (1155 km southwest) until August 30. Ten days later, from September 6 to 8, a ship 532)–6076 km to the west received a thin dusting of fine ash. By the morning of August 28, however, when daylight returned to the Sunda Straits, two thirds of the island of Krakatau had disappeared, leaving a spectacular, 800-m-high cliff displaying a natural cross-section of the volcano. To the north lay several new islands and banks of steaming tephra where the sea had been 36 m deep. Passing sailors described small, secondary explosions, "similar to the blowing of a whale," where these hot tephra banks interacted with cold seawater.

The impact of the 1883 Krakatau eruption was unquestionably great in the nearby areas of Java and Sumatra, but, perhaps of even greater importance, the effects were felt around the globe:

- Every recording barograph in the world documented the passage of the major airwave, some as many as seven times as the wave bounced back and forth between the eruption site and its antipodes (located near Bogota, Colombia) for 5 days after the explosion.
- Tide gauges recorded the principal seawave's passage far from Krakatau. The wave reached Aden, a distance of 7000 km, in 12 hours, and air-in-sea coupling of the airwave produced sea-level disturbances as far away as San Francisco and the English Channel.
- Blue and green suns were observed as fine ash and aerosol that erupted perhaps 50 km into the stratosphere and circled the equator in 13 days.
- Three months after the eruption these products had spread to higher latitudes, causing such vivid red sunset afterglows that fire engines were called out in New York City; Poughkeepsie, New York; and New Haven, Connecticut, to quench the apparent conflagration in the western skies. Unusual sunsets persisted for 3 years.
- The volcanic dust veil that created such spectacular atmospheric effects also acted as a solar radiation filter, lowering global temperatures as much as 0.5°C in the year after the eruption and not returning to normal until 1888. Locally, temperatures dropped 7°C in the darkness of noon on August 27.
- Rafts of floating pumice, locally thick enough to support men, trees, and no doubt other inadvertent biologic passengers, crossed the Indian Ocean in 10 months at speeds of 22–25 km per day.

The distant observations, combined with widespread reports about the eruption itself, stimulated multidisciplinary interest in Krakatau through intellectual feedback and cross-fertilization and the realization that geologists, hydrologists, meteorologists, and artist observers of the evening sky all contribute to an understanding of such a huge geophysical event. No doubt the disastrous loss of so many lives helped to capture the attention of the public, but we believe that Krakatau's fame comes mainly from the fact that its distant effects were observed by such a large part of the world's population—at a time when rapid communication via newly emplaced telegraph cables and publication of news made people aware of the connection between the eruption and their own observation of its effects.

Thus, the fame of the Krakatau eruption rests on firm foundations, and its importance to science has been undeniably great. It greatly advanced our geologic understanding of calderas. These large, circular depressions (such as Crater Lake, Oregon) are well known in volcanic regions, but in 1883 they were only just being named. Verbeek, the Dutch mining engineer studying Krakatau immediately after the eruption, correctly deduced that the missing portion of the island had collapsed into the subsurface void left by the eruption of huge volumes of pumice. Alternative explanations, such as the forceful blasting out of the missing portion of Krakatau, have not been supported, and Krakatau remains a type example of caldera collapse.

Kiessling called the eruption a "turning point in history for the science of meteorology" for its contribution to understanding of stratospheric circulation patterns, optical effects (and climatic impact) of fine particles at high altitudes, and propagation of explosive waves through the atmosphere.

Oceanographers have learned from the giant seawaves, and biologists have extensively studied the rapid return of life to these islands covered in 1883 with 30–100 m of hot pumice and ash.

The principal importance of Krakatau, however, is that it was a large, natural event with extraordinary impact on the solid earth, the atmosphere, and the oceans. This impact came at a time of great growth in science, technology, and communication, resulting in swift attention to this important event. The world quickly learned that the impacts of large geophysical events are global, and that they demonstrate the interdependence of land, sea, and air. Krakatau 1883 remains today a classic geophysical event with much yet to teach us about our world.

Forum

Committees Active Against Creationism

In 1981 in Federal District Court, Judge William R. Overton held that the Arkansas law mandating equal time for the teaching of "scientific creationism" in the state's public schools was unconstitutional. The Overton decision was the latest in a series of legislative and judicial setbacks suffered by fundamentalists who advocate the introduction of creationism into schools, libraries, museums, and other public institutions.

But rather than giving up the ghost, creationists are now switching their campaign into a series of local confrontations. In California the teaching of creationism in San Jose high schools is defended while the use of an evolution-oriented high school biology text is attacked. In Iowa an ambitious effort to introduce shoddy creationist paperbacks into the schools of 60 communities has just bogged down. In Michigan an exhibit on plant development in a modest, county-run museum is characterized as "blasphemous" because of the exhibit's evolutionary tone. So it goes across the United States and Canada.

The Committees of Correspondence (C/Cs), headquartered in Iowa, are a continent-wide communications network working at grassroots levels to defend the teaching of evolution from such creationist incursions. Founded in December 1980, the C/Cs now encompass 55 committees in 48 states and 4 Canadian provinces. While each committee is independent and autonomous, the various C/Cs cooperate with each other and with societies such as AAAS, American Geological Institute, Society of Economic Paleontologists and Mineralogists, and other scientific and educational groups. Membership of the C/Cs comprises scientists, nonscientists, and lay people.

The rationale of the C/C movement is that the creation/evolution controversy is not intellectual, scientific, or religious; it is basically a dispute over public policy. In the United States and Canada such disputes typically are resolved in local communities at the grassroots level. This is where the creationists operate, where proevolutionists must operate if they are to be effective, and where the C/Cs do operate. In this arena such formal procedures as passing resolutions are futile. Instead, both creationists and evolutionists stress the direct and active involvement of concerned individuals.

Methods used include generating publicity by publishing various materials, using TV programs, and calling radio talk shows; appearing before clubs, church groups, public meetings, PTA's, and other community organizations; and testifying before school boards and legislative committees. Such activities have long been used to good effect by all kinds of special interest groups. The C/Cs have found them productive in blocking creationist initiatives in such a degree that creationist speakers and publications now regularly denounce the C/C's and complain of our successes.

Members of AGU are invited to join in the C/C defense of evolution. Whether you join a committee or not, you may want to subscribe to *Memo to C/Cs*, the newsletter of the C/C national office. The *Memo* comes out five to nine times a year with current news items from both sides of the creation/evolution controversy; it costs $5 per year for C/C members, $8 for nonmembers, payable to Committees of Correspondence.

To join the C/C active in your state or province, or to subscribe to *Memo to C/Cs*, send your name, affiliation (or profession or occupation), work and home addresses, and work and home phone numbers to Committees of Correspondence, 156 East Alta Vista, Ottumwa, IA 52501.

Stan Weinberg
President
National Committees of Correspondence

News

Salton Sea Research Well

Two University of California, Riverside, scientists propose to extend a planned 3.7-km-deep steam-production well in the Salton Sea geothermal field to 5.5 km for scientific study prior to the well's commercial use. The Salton Sea, a hydrothermal-magmatism system in the delta of the Colorado River, is one of the hottest, most saline geothermal fields known and the proposed extension would make the hole the deepest geothermal well in the world. The investigators expect that, unless temperature reversals occur, bottom-hole temperatures in the extended well should exceed 400°C.

Investigators interested in participating in the study are being invited to submit funding proposals.

By the end of 1983, Republic Geothermal, Inc., plans to begin drilling a series of production wells in the eastern part of the Salton Sea geothermal field to supply steam for a future power plant. The first well in the series, planned to reach 3.7 km, will be the deepest yet drilled in this field. Temperatures in the two nearest complete wells, which bracket the site of the proposed well, reached 265°C at 2800 m, with a linear temperature gradient of 0.087°C m^{-1}. Fluids produced from these wells were sodium, calcium, and potassium chloride brines with 250,000 ppm total dissolved solids and high metal contents similar to brines from other parts of the field.

Republic Geothermal responded favorably to a request from investigators at the University of California, Riverside, to make the first well available for scientific studies before it is brought on line as a steam producer. Accordingly, a three-phase project was proposed. In phase 1 of the project, a series of five cores, cuttings, repeated water samples, and a comprehensive suite of wireline logs would be collected in the 3.7-km well. The lower 150 m would be cored continuously, testing new core retrieval techniques.

If drilling begins at the end of 1983, phase 2 would begin by the end of 1984, at which time the well would be re-entered and cored continuously to a total depth of 5.5 km. Comprehensive suites of wireline logs would be taken, and several drill stem tests would be attempted, followed by a fracture stimulation test. During the succeeding 9 months, further scientific downhole tests would be possible; this phase would be ended by bringing the well into production.

Phase 3, beginning at about the same time as phase 2, is the acquisition of other data from the deepened hole and scientific study of all the samples and data. It is for phase 3 that proposals to participate in the project are now being sought.

The project is subject to final negotiations with Republic Geothermal and its partners. Funding proposals for the first two phases of the project are under review by federal agencies; although this funding is not yet firm, specific plans for the scientific investigations in the deepened hole (phase 3) must be initiated immediately. Scientists interested in participating in phase 3 should call one of the following: Wilfred A. Elders, Principal Investigator, telephone 714-787-4501, or Lewis H. Cohen, Co-Principal Investigator, telephone 714-787-6020, or write to: The Salton Sea Scientific Drilling Project, Institute of Geophysics and Planetary Physics, University of California, Riverside, CA 92521.

A Steering Committee charged with scientific oversight of the project, is composed of Wilfred A. Elders (Chairman), University of California, Riverside; Keir Becker, Deep Sea Drilling Project, Scripps Institution of Oceanography, University of California, San Diego; Lawrence M. Cathles, Chevron Oil Field Research Co., La Habra, California; Alfred G. Duba, Lawrence Livermore National Laboratory, Livermore, California; and Robert O. Fournier, U.S. Geological Survey, Menlo Park, California. A well-site operations committee is also being formed. To advise on the scientific program, the Institute of Geophysics and Planetary Physics of the University of California has formed several panels under the general chairmanship of Orson L. Anderson, University of California, Los Angeles.

The Continental Scientific Drilling Committee (CSDC) of the National Academy of Sciences reviewed and commented on the scientific objectives of the research drilling project:

> The extended hole stands an excellent chance of yielding new and important scientific data on the Earth's thermal processes. The project is compatible with the convictions of the Committee, evolved over two years of careful deliberations, that, in order to achieve important advances in our fundamental understanding of thermal processes, the United States should initiate a new, highly focused scientific drilling program aimed at understanding the roots of hydrothermal systems related to young magmatic intrusions.

This news item was contributed by Wilfred A. Elders, University of California, Riverside, CA 92521.

Radiance Imaging and Rainfall

Upwelling radiation from the earth's surface has been found to be a successful indicator of the rate of rainfall, according to new analyses of data obtained by the Nimbus 7 and Seasat satellites. In a recent report describing the functions of the Scanning Multichannel Microwave Radiometer (SMMR) on these satellites, R. W. Spencer, D. W. Martin, B. B. Hinton, and J. A. Weinman of the Space Science and Engineering Center at the University of Wisconsin demonstrated that microwave emissions at the frequencies 37, 21, 18, 10.7, and 6.6 GHz are sensitive to changes in the rain rate (*Nature*, July 14, 1983). The results are significant because other satellite methods for the measurement of precipitation, which operate in the visible and infrared frequency ranges, infer precipitation from cloud observations.

The results of Spencer et al. are a comparison of SMMR U.S. data with rain rates derived from local weather radar observations. The comparison was done by digitizing radar plan position indicator photographs which are taken routinely by the U.S. National Weather Service. These rates and microwave brightness temperatures were entered in the University of Wisconsin Man–computer Interactive Data Access System. The output was displayed as television images and the radar brightness rain scale was contrasted with the SMMR images.

Microwave data at 37 GHz were found to be related to rain rates, linearly. This relationship was linear to rain rates up to at least 40 mm h^{-1}. The lower brightness temperatures corresponded to the heavier rain rates. The rain rate, R, is related to microwave brightness temperature, T_b, by

$$R = a_0 + \sum_{i=1}^{i=7} a_i T_i$$

the result of regression analyses of the data.

In the stepwise multiple-linear regression procedure used in the analysis, the terms with negative coefficients are due to relations between the upwelling radiation from land and its attenuation by rain. Positive coefficient terms are due to background temperatures of the land adjacent to raincells. According to the report, "The brightness temperatures represented by these terms respond less to radiations from rain because the radiometers have coarser spacial resolution and measure radiation at longer wavelengths compared with the drop size of rain." The rain areas and land areas are sampled for the analysis. The satellite SMMR system correlated with radar measurements with a coefficient of 0.80.—*PMB*

In Congress

Science Exchanges

Dwindling scientific and technical exchange between the United States and the Soviet Union and prospects for enhancing such exchanges were discussed at an August 2 hearing by the Foreign Affairs Committee of the U.S. House of Representatives. The committee also heard overviews on the United States' approach to international exchange of science and technology. The hearing was the first in a series on current and future international science and technology programs.

Four of eight science and technology agreements with the USSR that have expired in the last 15 months, including one on space, have not been renewed. The remaining four agreements have been extended into 1987 and 1988. Two others, including one on oceanography, are scheduled to run out in 1984.

The "widening" contacts with the Soviet Union, testified National Academy of Sciences (NAS) President Frank Press, result from "the concern of our own government about technology transfer; a further desire by government to restrict cultural, educational, and scientific contacts as a means of punishing the Soviets for their international actions in Afghanistan and Poland; the continuing secretive nature of Soviet society and the bureaucratic impediments imposed by the Soviet government; the politicization of the Soviet process for selection of exchange scientists; and finally, the abhorrence on our part of the abrogation of human rights of Soviet scientists."

"Each of these impediments can alone seriously endanger the sensitive thread of communication that exists today between our scientific communities," Press said.

NAS has conducted a scientific exchange program with the Soviet Academy of Sciences for nearly a quarter of a century. "The current reduced level of the interacademy program represents an unsatisfactory state of affairs in the view of many members of the [NAS]," Press added.

New formal agreements with the Soviet Academy, Press testified, "must assure (1) approximate reciprocity on both sides, (2) selection of topics of significant interest to the two scientific communities, (3) inclusion of fields of science in which both countries are leaders, (4) establishment of the principle that each Academy can invite scientists from the other country and that they will be included in the exchange program, and (5) clear understanding that all participants are mutually agreed upon in advance. I suggest that only in this way can we recapture the quality, enthusiasm, and excitement that characterized the early years of interacademy cooperation."

William Schneider, Jr., under secretary of state for security assistance, science, and technology, told the House Foreign Affairs Committee that the current level of cooperative science and technology activity is roughly one-fifth that of 1979. He "does not foresee any early return to cooperation with the Soviet Union on a scale matching that of the mid-seventies [when 11 bilateral agreements were established], and certainly not until the political factors that led to reduction in cooperation improve."

George A. Keyworth II, science advisor to President Reagan and director of the Office of Science and Technology Policy (OSTP), testified that the United States bases its cooperation with the Soviet Union in science and technology on three principles: maintaining a basic framework for scientific cooperation "so that, in the event that the political situation improves, we could expand and intensify beneficial exchanges with the USSR as expeditiously as possible"; to maintain those programs that clearly benefit the United States or "are of clear humanitarian importance"; and to keep a closer guard on science and technology that could have military applications.

Concerns that U.S.-Soviet cooperation could transfer technological expertise in security-sensitive areas have been voiced loudly in the past year. Last autumn an NAS panel concluded that although a substantial technology transfer does occur, open communication about federally funded research was not damaging national security (*Eos*, October 19, 1982, p. 897; October 5, 1982, p. 801; April 20, 1982, p. 241). The Department of Defense and OSTP currently are studying security concerns. In Congress, amendments to the Export Administration Act, which includes provisions for the export of scientific and technical information, have been introduced into the House of Representatives and the Senate and are expected to be considered when Congress resumes in mid September.

Three U.S. bilateral science agreements with other countries that have received much recent attention are with India (*Eos*, April 26, 1983, p. 153), the People's Republic of China, and Brazil. In addition, the United States works closely with European countries in space science programs and with nations from all over the globe on ocean drilling. More than a dozen government agencies administer cooperative projects with other nations. The National Science Foundation (NSF) alone administers some 400 science and technology cooperative projects with 30 countries. NSF's bilateral relationships with foreign countries increased twofold in the last 5 years, primarily through new ties with Western Europe, according to Richard J. Green, assistant director for scientific, technological, and international affairs at NSF.

In his testimony, Rep. Don Fuqua (D-Fla.), chairman of the House Science and Technology Committee, asked whether the science attachés and counselors at U.S. embassies are fulfilling their potential and whether these U.S. officials are receiving the strong support of the State Department. Among the other questions raised by Fuqua are whether cost-sharing arrangements are included in international science projects; how such projects can aid Third World development; and what the outlook is for the annual report entitled *Science, Technology, and American Diplomacy*, the "Title V Report."

Clement J. Zablocki (D-Wisc.), chairman of the House Foreign Affairs Committee, expressed deep concern about the Reagan administration's proposal to eliminate the annual "Title V" report and to fold it into President Reagan's biannual report on science and technology to Congress. Some, including Fuqua, feel that the "Title V" report "provides not only a comprehensive review of science and diplomacy, but is also an incentive for the Department [of State] to bring together and review annually all of its activities in this area."

Under Secretary Schneider told the committee that a biannual report would be more comprehensive than a yearly report and would be put into the context of the USTP report to Congress.—*BTR*

Radioactive Waste Study Released

A National Research Council (NRC) panel has concluded that the technology for safely storing radioactive waste is ready for confirmation in a test facility. At the same time, the panel proposed safety standards that are more stringent than standards currently proposed by some government agencies. The report, *Study of the Isolation System for the Geologic Disposal of Radioactive Wastes*, was funded by the Department of Energy as part of its effort to comply with a Congressional mandate to open a national radioactive waste storage facility by the end of the century.

The Waste Isolation Panel of the NRC's Board on Radioactive Waste Management did not choose a specific site for the first U.S. repository because the state of current technology does not allow the U.S. to design, construct, and safely operate a full-fledged site. However, the panel's chairman, Thomas H. Pigford, of the University of California at Berkeley, believes that the goal established by Congress can be met.

The containment options that the panel suggested for immediate testing involved systems (1) with a long-term absence of groundwater, (2) with low solubility of the waste or some factor in the geologic environment providing containment, or (3) with contamination being diluted by a large body of water.

Various federal agencies have proposed portions of the performance criteria needed for evaluating and designing a geologic storage system, but a comprehensive set of guidelines has never been advanced. The panel took issue with several of these agencies' individual proposals and adopted a comprehensive package of performance criteria of its own.

The panel rejected the Environmental Protection Agency's (EPA) proposal that safety limits be based on "population doses" (sum of doses to all individuals in a specified group), citing uncertainties over numbers, location, and eating habits of populations in the future. Instead, the panel felt that individuals may be better protected from overexposure by setting safety limits that assure that "maximally exposed individuals" do not receive more than 10^{-4} sieverts (Sv) per year of radiation from a radwaste site (1 Sv = 100 rem). This dose is equivalent to about 50% of the radiation a person receives from the average gamma background.

In a significant departure from the proposed EPA standard of allowing a 10,000-year time limit for measuring the effectiveness of a storage site and its mechanisms, the panel took into consideration future radiation doses "for all times as long as potentially important doses were predicted to occur." The panel felt that the 10,000-year limit may lead to distorted evaluations of the safety and effectiveness of the components in the storage system.

In its analysis of repository design the panel also questioned the Nuclear Regulatory Commission's proposal that repositories be designed for easy retrieval of waste in the future. The panel felt that the technological uncertainties were too significant, the safety risks too great, and the costs too high for implementing this proposal. Instead, to reduce or eliminate second guessing, the panel stressed the importance of carefully studying all components of the system before employing it.

The study focused on the wastes generated by the reprocessing of uranium fuel used in commercial light-water reactors. According to the U.S. Energy Information Administration this civilian waste is accumulating in a rate of approximately 1200 tonnes per year, with more than 8000 tonnes already in storage. This waste is being packaged as concentrated salt solutions or salt cakes in steel tanks, or if the waste generates significant heat, in cooling pools.

Salt, tuff (volcanic ash rock), granite, and basalt were considered by the panel as candidates for the primary geologic storage medi-

News *(cont. on p. 516)*

EOS
Transactions, American Geophysical Union
The Weekly Newspaper of Geophysics

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Subscription price to members is included in annual dues ($20.00 per year). Information on institutional subscriptions is available on request. Second-class postage paid at Washington, D. C., and at additional mailing offices. *Eos, Transactions, American Geophysical Union* (ISSN 0096-3941) is published weekly by

American Geophysical Union
2000 Florida Avenue, N.W.
Washington, D. C. 20009

Cover. Scenes of chaos and destruction produced by the 1883 eruptions of Krakatau. The photograph on the right, taken by a photographer named Hamburg on May 27, 1883, during the early and less destructive phase of the eruption, was brought to public light only this year. August 26–27 marks the 100th anniversary of the cataclysmic phase of the eruption, which remains one of the most renowned geophysical events in history. See article, p. 513.

New Editors' Addresses

Authors submitting manuscripts after October 1, 1983, to the Aunospheres or the Oceans sections of the *Journal of Geophysical Research* (JCR) or to the policy sciences portion of *Water Resources Research* (WRR) should send them to their new editors at the following addresses:

JGR–Atmospheres
William L. Chameides, School of Geophysical Sciences, Georgia Institute of Technology, Atlanta, GA 30892 (telephone: 404-894-3883).

JGR–Oceans
James J. O'Brien, Editor
P.O. Box 2173 Tallahassee, FL 32316
(telephone: 904-644-4581).

WRR, policy sciences
Ronald C. Cummings, Department of Economics, University of New Mexico, Albuquerque, NM 87131 (telephone: 505-277-3056).

News (cont. from p. 515)

um. While each of the media had advantages and disadvantages as a storage environment for most radioactive byproducts, salt seemed to be the most promising option because of the absence of groundwater near most salt deposits.

The risk that groundwater would transport hazardous waste away from the immediate containment area was an important consideration in the study. In one scenario there is a long-term absence of groundwater. (In this respect salt repositories have an advantage over other media for storing low-level waste.) In another scenario slow-moving groundwater is present, but the geology of the area has some unique containment feature. In some cases, if the groundwater does reach the surface, the radiation could be further reduced by dilution in a large body of moving water. This dilution may reduce the radiation to a point where no individual is exposed to doses larger than the panel's imposed limit of 10^{-4} Sv yr^{-1}.

In dealing with groundwater transport, the study also incorporated new research that suggests that the low solubility rates of some elements (e.g., neptunium and uranium) may provide an additional safety margin even if water permeates the waste package.

Among its many recommendations the panel also called for additional testing of waste package components under the greater heat stress that future waste is likely to generate. While current waste has had an opportunity to cool above ground, any new waste introduced directly into a repository may challenge the safety limits of some current designs.

The report also discussed in detail several conceptual plans for repositories and designs for storage packages.

The scope of the study was limited to issues directly related to radioactive waste storage in geologic formations and did not deal with such topics as the future of nuclear energy, the hazards of transporting nuclear fuel, disarmament policy, and the storage of radioactive waste generated by the military. The panel did not address proposals for dumping waste into outer space or on or beneath the ocean floor, though the panel briefly suggested that more research be conducted on the ocean option.

The 345-page report is available from the National Academy Press, 2101 Constitution Ave., N.W., Washington, DC 20418.—BD

Books

Ocean and Coastal Law

R. G. Hildreth and R. W. Johnson, Prentice-Hall, Englewood Cliffs, N.J., xxix + 514 pp., 1983, $38.05.

Reviewed by David A. Ross

First of all, this is not the typical book that one expects to see reviewed in *Eos*, but, read on. It should be clear, by now, even to the most esoteric geophysicist, that lawyers and jurists are taking very close looks at many coastal zone and offshore marine activities. More importantly, there are a wide variety of laws (both at the state and the national levels) and international regulations that determine how we now use or will use our coastal region including how and where we will do marine scientific research. Recently, a Presidential Proclamation (March 1983) declared a 200-mile exclusive economic zone for the United States. The President, in the accompanying statements to the Proclamation, has called special attention to polymetallic sulfide deposits (Is someone in the White House reading *Eos*?) in what will now be U.S. waters (i.e., the Juan de Fuca region). Well, if you or your colleagues want to know more about U.S. and individual state rules for management and use of our marine areas, this might be the book for you.

Ocean and Coastal Law is primarily intended as a law school text, and the authors have used informal editions at their respective universities (University of Washington, University of Oregon) for teaching law courses. The book basically looks at three marine regions: first, the land area affected by the sea; second, coastal waters and the seabed of the territorial sea (to 3 nautical miles); and, third, more offshore waters and their resources beyond the territorial sea out to the edge of the continental shelf but including the present 200-mile U.S. fisheries zone. The basic organizational format is to look at the problems that existed prior to management and regulations and then consider questions of ownership and boundaries of the different regions. Much attention is paid to state common law because it often preceded the development of a more national approach to the coastal region.

Following an introduction, the chapter headings are Ownership and Boundaries in the Coastal Zone; State Common Law and the Coastal Zone; State-Federal Relationships Offshore; Living Resource Management; Nonliving Resource Management; Oil Spills; Disposal of Wastes in the Ocean; Comprehensive Ocean Management; Alteration of Coastal Waterways and Wetlands; The Federal Coastal Zone Management Act; and Legal Issues in State Coastal Zone Management. The last chapter looks specifically at legal issues in North Carolina, Florida, Georgia, California, and Washington.

The book is not just a compilation of laws (although there are many of these) but also includes considerable discussion (generally from some official record) of the key points. It is written in somewhat of a legal manner with direct and often abrupt quotes from various references, statutes, and court cases, a style common (I am told) to traditional law texts. Sections end sometimes in mid-sentence, having made the legal point, but, generally, enough material is presented for an understanding of the key points by non-lawyers. The examples of ocean use and case studies are strictly from the United States; in some instances (like oil development management and pollution control or fisheries management), foreign information might have been useful. Likewise, Law of the Sea issues (especially recent ones like marine scientific research) are neglected. However, these are often taught as a separate course in most schools.

In conclusion, it was an interesting book for me but is obviously not a book that should be in every oceanographer's library. However, it would be a good idea if everybody interested in the coastal area at least knows somebody who has a copy.

David A. Ross is a senior scientist and Director of the Marine Policy and Ocean Management Center at Woods Hole Oceanographic Institution, Woods Hole, MA 02543.

Carbon Dioxide: Friend or Foe?

S. B. Idso, IBR Press, Tempe, Arizona, xiii + 92 pp., 1982.

Reviewed by C. Muller

Carbon Dioxide: Friend or Foe is a short monograph on the so-called carbon dioxide greenhouse effect. The author challenges the established view that the present CO_2 increase would, in the long term, lead to a global ground temperature increase. S. B. Idso, from four sets of observations, has deduced that the temperature response to an increased received energy at the ground should be less than or equal to 0.113 K (W/m^2). If this result is combined with the 2.28 W/m^2 of increased radiation expected from CO_2 doubling, he finds a temperature increase of 0.26 K, which cannot be distinguished form the natural temperature fluctuation. This conclusion is in disagreement with virtually all the current mathematical models that predict a ground temperature response of an order of magnitude or more higher.

The book is divided into eight chapters; the first five describe the history of the CO_2 climate theory since its introduction by Tyndall in 1861, the shortcomings of the current climate models, and, finally, the experimental evidences that led Idso to propose his empirical response function. In chapter 6, Idso stresses the interaction between a CO_2 increase, even if the temperature stays constant, and the yield of crops that, far from being adversely affected, would in some cases be greatly magnified. Beside its direct significance, which is Idso's main concern, a more active biosphere would provide the modeler with a biomass feedback that could limit the CO_2 growth. The two last chapters present a comment on the attitude of the official committees set up by the National Academy of Sciences to deal with the CO_2 climate issue. Idso might be right when he hints that these committees were composed of scientists of similar approaches who refused to consider any theories or results coming from outside their group. It happened too often during the last decade that similar bodies were formed in decreed that their majority opinion was the absolute scientific truth.

Despite the unconventional character of Idso's theory, it is fair to admit that under the present state of our knowledge it is not obvious how it could be refuted. The only place where the author's argument is contradicted by simple evidence is at the end of chapter 5 where he says that the decrease in temperature observed in the northern hemisphere since 1945 and the opposite trend in the southern hemisphere are due to differences in CO_2 variations, both CO_2 increases being in fact parallel, the south lagging merely by maybe a few months. The best defense of the modelers, to my point of view, is to be found in the work of J. Hansen et al. (Climate impact of increasing atmospheric carbon dioxide, *Science, 213*, 956–966, 1981), which, beside explaining clearly what the greenhouse effect is all about, is able to reproduce Idso's empirical response function and explain it in terms of ocean damping. Their elaborate models find that after a CO_2 doubling and several years of equilibrium, the ground temperature increases by about 3 K, in agreement with most of the other models.

Nevertheless, the book can still be recommended for the physicist dealing with the climate problem because it stresses the importance of the atmosphere-clouds-ocean-ice-biomass interaction system and invites every modeler either to extend the model or to try to parametrize those effects that are beyond the possibilities of any current modelization.

C. Muller is with the Belgian Institute for Space Aeronomy, B-1180 Brussels.

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POSITIONS AVAILABLE

Geophysicist. New Mexico Institute of Mining and Technology invites applications for a tenure track position in exploration seismology at the assistant professor level to begin as soon as possible. The position will be a joint appointment between the College Division and the Research and Development Division. A PhD is required. Send letter of application, resume, brief description of teaching and research interest and names of three references to: Personnel, Brown Hall 17, New Mexico Institute of Mining and Technology, Socorro, NM 87801.

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University of Minnesota Stratigrapher/Sedimentary Petrologist. Tenure-track position starting Fall 1984, probably at the Assistant Professor level. The candidate must have a Ph.D. with interest in stratigraphy of sedimentary basins, tectonics and sedimentation, and sedimentary petrology, and will be expected to carry out research and to teach graduate and undergraduate courses in these fields. Please submit resume, academic records, and three letters of recommendation to Dr. Peter J. Hudleston, Department of Geology and Geophysics, 108 Pillsbury Hall, University of Minnesota, Minneapolis, MN 55455 (612)373-3379.

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Structural Geologist/University of Maryland. The Department of Geology, University of Maryland at College Park, seeks a structural geologist to fill a tenure-track position at the Assistant Professor level by August, 1984. The applicant should have a commitment toward quality research and can contribute to a rapidly developing M.S. and Ph.D. program as well as an established undergraduate component. Teaching responsibility includes structural geology, tectonics, and applied geophysics.

The College Park campus is located in the Washington metropolitan area close to USGS, Carnegie Institute, Smithsonian Institution, NBS, and U.S. Bureau of Mines. The University computer facilities consist of two Univac 1180 computers, three IBM 4341 computers, and several hundred remote terminals. Departmental facilities include basic geophysical exploration equipment, rock preparation equipment, high-temperature and high pressure equipment for mineral synthesis and equilibrium studies, XRF, XRD, AA, and microprobe.

For full consideration, applicants possessing Ph.D. should send a curriculum vitae, three letters of reference, and a description of research to R. L. Nielsen, Chairman, Search Committee, Department of Geology, University of Maryland, College Park, Maryland 20741.

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The University of Washington is an Equal Opportunity/Affirmative Action Employer. Oceanography Advertisement No. 833.

University of California/Assistant Researcher. Scripps Institution of Oceanography invites applications for the position of Postgraduate Researcher through Assistant Researcher. Appointment as Assistant Researcher requires a publication record. The position is in the upper ocean physics group of the Marine Physical Laboratory. Active research areas include air sea interaction, internal wave and mixed layer studies, as well as doppler acoustic sensor design. Candidates should have a Ph.D. in Oceanography, Physics or Engineering as well as experience and a desire to participate in field research. Salary range: $15,936 to $26,800. Send curriculum vitae and names of references to Professor Robert Pinkel, Marine Physical Laboratory, Scripps Institution of Oceanography, UCSD, San Diego, CA 92152. Closing date: August 31, 1983.

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Hydrogeologist, Hydrologist, or Water Resources Planner. The Kansas Geological Survey, a division of The University of Kansas, solicits applications for a hydrogeologist, hydrologist, or water resources planner. Permanent, full-time position subject to annual review. Salary Range: $20,000–$30,000 per year, depending on qualifications. Required qualifications: Master's degree in hydrogeology, hydrology, or related water resources field. Course work in theoretical hydrologic modeling and capability to apply these models to different hydrologic and water planning problems to particular areas in Kansas. Preferred qualifications: Ph.D. degree in one of the above fields, and 2–3 years of research experience in water resources related studies.

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Contact Personnel Manager, Kansas Geological Survey, 1930 Constant Avenue, Campus West, The University of Kansas, Lawrence, Kansas 66044 (Ph. 913/864-3965) for full position description, or to apply, send resume, college transcripts, list of published research, and three letters of reference. Priority will be given to applications received by October 31, 1983. Applications will be accepted and reviewed every thirty days thereafter until the position is filled.

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Iowa State University of Science and Technology, Department of Earth Sciences. Applications are invited for a tenure track faculty position in Meteorology. Rank is at the assistant or associate professor level dependent upon qualifications. The successful applicant will be expected to develop a strong research and graduate student program and will teach undergraduate and graduate courses for meteorology majors.

The position is for a person with proven expertise within the general area of dynamic meteorology. Teaching will involve an undergraduate course in synoptic meteorology, in addition to courses related to the field of expertise. Completion of the Ph.D. prior to appointment is strongly preferred. In addition, research ability shown by other publications and/or postdoctoral experience will be an advantage.

Iowa State offers degrees in meteorology through the Ph.D. The program includes about 60 undergraduate majors; the graduate/research program is strong and emphasizes theoretical, dynamic studies. Close relationships are established with the facilities and personnel of major national laboratories. New campus facilities for meteorology are currently under construction.

The appointment is expected to begin no later than September, 1984; an appointment during the current academic year may be possible. Application deadline is November 1, 1983; later applications will be accepted if the position is not filled. For application information please write to:

Dr. Bert E. Nordlie
Department of Earth Sciences
Iowa State University
253 Science I
Ames, Iowa 50011.

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Seismological Research Assistant/Weston Observatory. Will supervise the analyze of local earthquakes and the production of a seismic bulletin; assist in equipment maintenance, field experiments and related duties. Requires a Master's degree in Geophysics or a related discipline as well as programming experience in FORTRAN (PASCAL and C also desirable). Must be familiar with digital signal processing and the theory of seismic wave propagation. To apply send letter and resume to Mary McMillan, Personnel Office, BOSTON COLLEGE, Chestnut Hill, MA 02167.

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Research Positions/Lunar and Planetary Laboratory. The Lunar and Planetary Laboratory at the University of Arizona has research positions open for Research Scientists. Researchers at the Laboratory have access to the University's observatories, a wide range of astronomical instrumentation, a complete collection of planetary images, computers and laboratory facilities. The research ranks in the Laboratory, namely Assistant Research Scientist, Associate Research Scientist, and Research Scientist parallel the tenure track ranks of Assistant, Associate and Full Professor. Salary levels are commensurate with equivalent tenure-track ranks. These are non tenurable and not state-funded positions. Researchers in these positions will be expected to supply a significant portion or all of their salaries through their grants and contracts.

Applicants should submit a curriculum vita, list of publications, and the names of three references by November 1, 1983, to L. L. Wilkening, Director, Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721.

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Supervisory Geophysicist. The National Oceanic and Atmospheric Administration (NOAA) announces a Supervisory Geophysicist, GS-13, vacancy in the National Geophysical Data Center, Solid Earth Geophysics Division, Boulder, Colorado. Starting salary at GS-13 level is $34,930. Duties include administrative and technical activities on behalf of the Branch; maintaining liaison with principal geophysicists nationwide; recommending to the Division Chief new techniques and services; serving on national working groups; and providing expert advice. An advanced knowledge of theoretical and practical applications of geophysical data, e.g., gravity, geomagnetism, seismic refraction and related disciplines is required. For further information and/or application procedures, please call Mary Plumley, NOAA Personnel, at (303) 497-3102. Applications must be received by Sept. 23, 1983 to be considered.

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Dr. Raymond A. Castillo
ASRC—Earth Science 324
State University of New York at Albany
1400 Washington Avenue
Albany, New York 12222

An Equal Opportunity Employer.

Research Scientist/Space Plasma Physics, University of Iowa. A research position is available in the Department of Physics and Astronomy, The University of Iowa, for theoretical and interpretative studies of waves in space plasmas. Specific emphasis is on theoretical investigations of wave-particle interactions in planetary magnetospheres and in the solar wind. These investigations are to support the interpretation of data being obtained from spacecraft projects such as Dynamics Explorer, International Sun Earth Explorer and Voyager. The applicant must have a Ph.D. with good qualifications in plasma physics theory and should have some experience in the interpretation of space plasma physics data.

Send a resume and the names of three references familiar with the applicant's work to: D. A. Gurnett, Department of Physics and Astronomy, The University of Iowa, Iowa City, Iowa 52242, telephone 319-353-3527.

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Tenure-Track Faculty Position-Geophysics/New Mexico State University. We are seeking a faculty member whose duties will include teaching both undergraduate and graduate level courses, conducting research and supervising graduate level thesis and dissertation research. We are particularly interested in a seismologist, but persons with experience in other geophysical techniques are invited to apply.

Minimum qualifications include an earned doctorate in geophysics or a closely related area and demonstrated research capability. Teaching experience and demonstrated ability to secure research funding are desirable. The position is available in January 1984 for 9-month academic year. Appointment will be at the rank of Assistant or Associate Professor. Salary and academic rank will be dependent on experience and qualifications.

Applications and names, addresses and telephone numbers of at least three references should be submitted to Dr. Chandler Swanberg, Department of Earth Sciences, P.O. Box 3AB, Las Cruces, NM 88003.

Applications received by October 15, 1983 will be given preference.

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The University of Missouri-Columbia/Faculty Positions. The University of Missouri-Columbia Department of Geology plans immediate expansion through the addition of three tenure-track faculty positions. Appointments are anticipated at the assistant professor level, although higher ranks may be possible, beginning in August of 1984. Candidates will be expected to have completed requirements for the Ph.D. degree by that time. Faculty members are required to provide quality instruction at both undergraduate and graduate level, and conduct research leading to scholarly publications. Successful candidates will be chosen from the following specialties:

Exploration Geophysics
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Hydrogeology
Analytical Structural Geology
Clastic Sedimentology

Applications should send resume, transcripts, and names and addresses of three references to:

Tom Freeman, Chairman
Department of Geology
University of Missouri
Columbia, MO 65211

Structural Geologist/University of Wyoming. The University of Wyoming, Department of Geology and Geophysics seeks applicants for a tenure track appointment in structural geology to be available beginning fall semester 1984 or earlier. Duties will include teaching of undergraduate and graduate courses in structural geology, supervising MS and PhD theses, and research in structural geology. Appointment at assistant professor level is preferred, but applicants requesting appointment at higher rank will be considered. Applicants must have a PhD degree and be versed in quantitative theory as well as field applications of modern structural geology and regional tectonics.

Applicants should provide a resume, names of three references and a letter of application including a statement of current research interests and courses which the applicant feels qualified to teach. Applications should be sent to: Dr. Robert S. Houston, Department Head, Department of Geology/Geophysics, PO Box 3006 University Station, Laramie, WY 82071.

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Send a letter of application, curriculum vitae and names of three references to:

Chairman, Search Committee
Department of Geological Sciences
Wright State University
Dayton, OH 45435.

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Meetings

Announcements

Arctic Air Chemistry

The Third Symposium on Arctic Air Chemistry will be held May 7–9, 1984, in Downsview, Ontario, Canada. The program will include presentations on gases and aerosols, natural and pollution sources, transport, transformation, deposition, and radiative and nucleational effects. A poster session is also on the agenda.

Abstracts must be submitted by October 1, 1983. Send abstracts to the symposium's host, L. A. Barrie, Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ontario M3H 5T4, Canada (telephone: 416-667-4785) or to the symposium's chairman, K. A. Rahn, Graduate School of Oceanography, University of Rhode Island, Narragansett, RI 02882–1197 (telephone: 401-792-6234).

Climate Symposium

A symposium on Climate: History, Periodicity, and Predictability will be held in New York City on May 21–23, 1984. The symposium is being dedicated to Rhodes W. Fairbridge in honor of his 70th birthday and in recognition of his significant contribution to paleoclimate research.

Papers scheduled for presentation at the meeting will examine past and present climate trends, predict future trends, and explore the possible causes and consequences of climate fluctuations. A major focus will be the cyclicity of climate change on various time scales and the relationship between climate cycles and such cyclic causal mechanisms as solar variations, the earth's orbital parameters, and other regularities in the dynamics of the solar system.

Because a tentative program based on accepted papers already has been set, the symposium's organizers have little latitude in accepting additional contributions. Approximately 50 papers are on the agenda.

Papers presented at this gathering will appear in a volume designed to serve as a landmark publication that will mark the progress made in climate research in the 20 years since Fairbridge organized a similar conference and and published its proceedings. The proposed coeditors for the volume are J. E. Sanders, W. S. Newman, M. R. Rampino, and L. K. Konigsson.

For more information contact John E. Sanders, Department of Geology, Barnard College, Columbia University, New York, NY 10017 (telephone: 212-280-4312).

Seismology Meeting

The International Association of Seismology and Physics of the Earth's Interior (IASPEI), one of the seven associations of the IUGG, will hold a regional assembly in Hyderabad, India, October 31 to November 7, 1984.

In addition to the the lectures, commission workshops, and plenary and administrative meetings of the association, the assembly will

Meetings (cont. on p. 518)

Meetings (cont. from p. 517)

include symposia on deep-seated processes in collision zones, seismicity and seismotectonics of Asia, terrestrial heat flow and thermal regimes, lithospheric structure beneath Asia, physics of the earth's interior, and the growth of geosciences in developing countries.

Following the meeting, scientific excursions are planned to the Kashmir Himalaya, Kumaun Himalaya, Darjeeling Himalaya, and Mahabaleshwar-Koyna-Goa. Field trips to the granulite-greenstone terrain in the Kolar gold mines area and the charnokite-granulite terrain of south India are also scheduled.

For more information, contact Mohan L. Gupta, Organizing Committee, IASPEI Regional Assembly, National Geophysical Research Institute, Hyderabad-500 007, India (telex: 155–478 NGRI IN; cable: GEOPHYSICS).

The assembly is being held in response to an invitation from the Indian National Committees for the IUGG.

Meeting Report

Chapman Conference on Magnetospheric Currents

A Chapman Conference on Magnetospheric Currents was held in Irvington, Va. during April 5–8, 1983. The purpose of this conference was to bring together theoretical and experimental researchers and students interested in electric currents in the earth's and other planets' magnetospheres. The knowledge in this area was reviewed and remaining questions were identified. Over 90 registrants from four continents (including countries such as Japan, Mainland China, Australia, Germany, Sweden, Norway, Denmark, and Canada) participated in formal presentations, poster sessions, and informal discussions. Some of the highlights and principal results of this conference are reviewed here.

It was very appropriate to have this conference as part of the series named in honor of Sydney Chapman, who contributed so much to our understanding of currents in the earth's ionosphere (Chapman was one of the first to suggest the existence of the cavity surrounding the earth due to the solar wind, which we now *call* the magnetosphere). The scientific contributions and personal reflections of Chapman and Birkeland were discussed in formal lectures by Alex Dessler and Alv Egeland. Chapman was 29 when Birkeland died in 1917, and the two great scientists never met formally. Birkeland was the first to develop polar current systems from surface magnetic field observations, and he provided the first classification of world geomagnetic disturbances in which the term "polar elementary storms" was coined. He was also the first to suggest the concept of field-aligned currents. Chapman, with Bartels, authored the great treatise, *Geomagnetism*, in 1940, and conceived "Dst" and the term "substorm" (with Akasofu).

The complex system of electric currents that flow throughout the earth's magnetosphere is now viewed as the unifying element in the complex solar-terrestrial system. Variations in the interplanetary magnetic field are conveyed to the near-earth polar regions by these currents, and they appear to be the basic constituent in important ionospheric plasma instabilities. A general introduction to these three-dimensional current systems was provided in review lectures by Akasofu, Olson, and Vasyliunas. Although electric circuits with lumped elements—resistors, capacitors, and inductors—were often invoked to describe these current systems, Vasyliunas made the point that "there are no wires in the magnetosphere" and that the sources of these currents involve complex plasma dynamics governed by the MHD relation between plasma flow and the earth's magnetic field configuration.

The systems of ionospheric currents deduced from surface geomagnetic measurements were reviewed by Richmond, Baumjohann, and Friis-Christensen, and the associated system of field-aligned currents deduced from low altitude spacecraft was described by Iijima, Burrows, Sugiura, Zanetti, and Bythrow. Richmond described his work with Kamide and others by which global systems of ionospheric currents are deduced from an international array of surface magnetometers. The deduced ionospheric current system is combined with models of ionospheric conductivity distributions in the polar and auroral regions in order to calculate electric field distributions and systems of Birkeland currents. The critical importance of the ionospheric conductivity in these studies was an active subject of discussion which prevailed throughout the conference. Although considerable work has been done in developing global statistical models of ionospheric conductivity (described by Reiff), the conductivity (or lack of knowledge thereof) appears to be the weakest link in developing accurate models of Birkeland currents and electric field distributions from surface magnetic field variations. The spectacular auroral images acquired by the Dynamics Explorer (DE) Satellite and shown by Craven and his colleagues was suggested as the most promising method of deducing "instantaneous" global conductivity distributions, although considerable work must be done in deducing electron density distributions from images.

The unique magnetic field measurements obtained with the MAGSAT satellite were presented in several talks. The very low altitude of MAGSAT (below 400 km) and high sensitivity of magnetic field measurements allowed both ionospheric and Birkeland current distributions to be inferred (described by Zanetti and Burrows). A novel color graphics technique of displaying global magnetic disturbance distributions observed by MAGSAT was shown by Bythrow. Sugiura and his colleagues showed high resolution measurements of magnetic and electric fields acquired with the DE-2 satellite which showed amazingly high degrees (better than 0.9) of correlation. The good correlation is interpreted as meaning that the Birkeland currents are coupled completely by Pedersen currents in the lower ionosphere. Sugiura also described Birkeland current filaments with densities as high as 800 $\mu A/m^2$, which have been measured by the DE Satellite. These observations support earlier measurements of very intense Birkeland currents from the S3-2 satellite by Burke and his colleagues. Burke described the relationship between these very intense currents and potential distributions and charge carriers near discrete auroral arcs. Burke has developed an explanation for the intense currents based on plasma instabilities which incorporate ion cyclotron instabilities and Kelvin-Helmholz unstable charge. These very intense Birkeland currents should be the source of great research interest for some time.

Observations of electric currents by satellite-borne magnetometers are difficult, if not impossible, at great distances from the earth where the geomagnetic field is very weak. Frank and Huang presented observations of field-aligned and cross-field currents in the magnetotail that were deduced from particle observations with ISEE-1. Frank and Huang concluded, from their particle distribution measurements, that the cross-tail neutral sheet current could not be attributed to curvature drift or gradient effects and must be driven by an electric field. Lui described characteristics of the cross-tail current inferred from IMP-5 and IMP-6 observations, and Hones described the "drapping" configuration of magnetic field lines near the magnetospheric boundary regions determined from ISEE observations.

Joseph N. Barfield (left) and Thomas A. Potemra celebrate the 10th anniversary of the launching of the Navy's TRIAD navigation satellite, from which a sensitive magnetometer is still providing accurate measurements of the earth's magnetic field (atop the cake is a small wooden model of TRIAD). The celebration occurred in Irvington, Va., during AGU's April 1983 Chapman Conference on Magnetospheric Currents, organized by Potemra and Barfield.

A search for the charge carriers of Birkeland currents was described by Klumpar. Upward flowing electron beams from DE-1 and upward streaming low-energy ions from S3-2 which could carry significant currents were presented by Reiff and by Saflekos, respectively. Reiff described various efforts in determining ionospheric conductivity models, and Robinson presented detailed correlations between the Chatanika radar and the TRIAD, AE-C, S3-2, and ISIS satellites aimed at an understanding of the way that ionospheric conductivity influences the distribution and intensity of Birkeland currents. A very interesting set of contributed papers by Spencer, Walker, Ahn and Akasofu, and Foster described the energy deposition and atmospheric effects associated with precipitating particles and field-aligned currents. Walker suggested the existence of a link between magnetic disturbances and stratospheric perturbations which may be related to Joule and particle heating. The evidence is mounting for a coupling between the low-altitude neutral atmosphere and the magnetosphere.

Distributions of electric fields in the auroral and polar regions measured with the OGO-6 and DE-2 satellites were reviewed by Heppner. These distributions reaffirm the close relationship between polar cap electric potential distributions and the interplanetary magnetic field. The electric field distributions deduced from the Chatanika, Millstone Hill, and STARE radars were described by Foster and Greenwald. Owing to the relatively low latitudes of these radar systems, the interesting patterns in the polar cap have not yet been obtained with surface radars. The results of the Sondre Stromfjord radar are anxiously awaited. Spiro reviewed modeling efforts that attempt to pull together the convection electric fields and Birkeland current distributions. The "Rice" model (developed by Spiro, Wolf, and their colleagues) appears to be very successful in accounting for many of the observed distributions.

There were several papers and considerable discussion on possible generation mechanisms of Birkeland currents in the outer magnetosphere. Papers on this subject were presented by Stern, Kan, Atkinson, Cole, Heikkila, and Olson. It is impossible to review thoroughly these presentations in this short report, but it is worth repeating a statement by Atkinson that may typify some of these new theories: "Field-aligned currents are the signatures of the redistribution of plasma in the magnetosphere." The "origins of Birkeland currents" may be the exciting new research area of the near future. Some new experimental information on this subject was described in a poster paper by Wygant and his colleagues. They correlated magnetic variations measured with ISEE-1 in the tail lobe with near-earth variations measured by S3-3 and TRIAD. These observations suggest that a constant proportion of the tail current system closes through the Region 1 Birkeland current system. This idea is in opposition to the suggestion that the cross-tail current system suffers catastrophic interruption.

Models of three-dimensional current systems were reviewed by Rich and Kamide, Hughes, and McPherron. An imaginative model of Birkeland current dynamics was described by Siscoe and Crooker. Their model approximates the distribution of Birkeland currents in the auroral zone by annular rings with characteristic inside (polar cap) and outside (equatorward) radii. These two radii change independently but with a definite relationship to substorm activity and IMF charges. Complex patterns and relationships are reduced to an understandable model with this format.

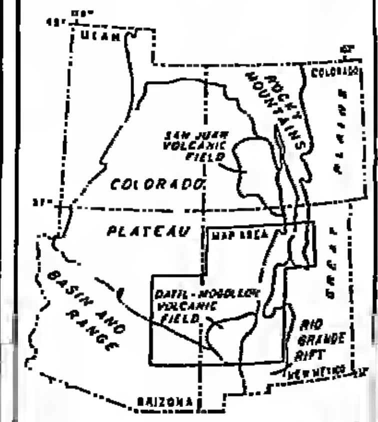
The importance of magnetospheric currents to ionospheric plasma instabilities was emphasized by the presentations by Samson, Burke, Block, Cattell, Vickrey, Aarons, and Saflekos. Both experimental and theoretical evidence is growing for the relationships of Birkeland currents with magnetic pulsations, auroral arcs, equipotential structures (and double layers and solitons), ion cyclotron waves, ion acceleration mechanisms, and ionospheric irregularities which produce scintillations.

The current systems at Jupiter, Saturn, Uranus, and Venus were described in review by Ness, Hill, Cloutier, and Barbosa. The current system at Uranus has not yet been directly measured, but Hill proposed an interesting "pole-on magnetosphere" which extracts energy from the planet's rotation in a manner analogous to the Faraday disc dynamo.

An AGU Geophysical Monograph containing many of the conference presentations is already in preparation. This volume will also contain historical review papers. Copies of the conference program and abstract book can still be obtained from the convenors.

The sponsors of the conference were The American Geophysical Union and the U.S. Panel of the International Magnetospheric Study. Financial support was provided by the National Science Foundation, NASA, Office of Naval Research, Air Force Geophysics Laboratory, Applied Physics Laboratory/The Johns Hopkins University, Southwest Research Institute, TRW/Defense and Space Systems Group, Ball Brothers/Aerospace Division, RCA Astro-Electronics, and Martin Marietta/Denver Aerospace.

This meeting report was prepared by T. A. Potemra, Applied Physics Laboratory, The Johns Hopkins University, Laurel, MD 20707, and J. N. Barfield, Southwest Research Institute, San Antonio, TX 78284.



Geophysical Year

New Listings

The complete Geophysical Year last appeared in the May 31, 1983, *Eos*.

A boldface meeting title indicates sponsorship or cosponsorship by AGU.

Jan. 28–Feb. 3, 1984 Conference on Planetary Plasma Environment, Yosemite, Calif. Sponsor, NASA. (J. H. Waite, NASA/Marshall Space Flight Center, tel.: 205-453-3037; or C. R. Clauer, Stanford Univ., tel.: 415-497-4691.)

April 24–27, 1984 Pacific Conference on Marine Technology (PACON 84), Honolulu, Hawaii. Sponsor, Marine Technology Society. (PACON 84, Center for Engineering Research, Univ. of Hawaii at Manoa, Honolulu, HI 96822, tel.: 808-948-7338 or 7449.)

May 7–9, 1984 Third Symposium on Arctic Air Chemistry, Downsview, Ont., Canada. (L. A. Barrie, Atmospheric Environment Service, 4905 Dufferin St., Downsview, Ontario M3H 5T4, Canada, tel.: 416-667-4785; or K. A. Rahn, Graduate School of Oceanography, Univ. of Rhode Island, Narragansett, RI 02882–1197, tel.: 401-792-6234.)

May 21–25, 1984 Symposium on Climate: History, Periodicity, and Predictability, New York, N. Y. (John E. Sanders, Dept. of Geology, Barnard College, Columbia Univ., New York, NY 10017; tel.: 212-280-4312.)

June 10–15, 1984 65th Annual AAAS Meeting (Pacific Division), San Francisco, Calif. (Alan E. Leviton, Executive Director, AAAS (Pacific Division), California Academy of Sciences, Golden State Park, San Francisco, CA 94118, tel.: 415-752-1554.)

AGU

Membership Applications Received

Applications for membership have been received from the following individuals. The letter after the name denotes the proposed primary section affiliation.

Jordan C. Alpert (A), Stephen F. Barrett (T), Alan P. Biddle (SM), George R. Carignan, Susan M. Cashman (T), Sherren C. Clark (GP), Mark A. Cooper (T), Jeremy S. Delaney (V), Kenneth L. Denman (O), K. R. S. Devan (A), Terrence J. Donovan (GP), William Kappel (H), Clarence G. Kennedy (O), Malcolm K. W. Ko (A), Hyung Sun Lee (O), Hanspeter Luterbacher (O), Samuel R. Martin (H), Stuart A. McKeen (A), R. G. Murdock (S), Isamu Nagano (SM), Luigi Natale (H), Bent M. Pedersen (SM), William T. Petrachenko (G), Martin J. Rademakers (S), Ronald Rossmann (O), Alan Shopmyer (H), Jeffrey H. Smart (O), Carol L. Stein (V), Randell A. Stephenson (T), L. R. Owen Storey (SM), Peter Szatmari (T), J. Henry Tanner, Lloyd R. Townley (H), Robert N. Treuhaft (G), Wendy C. Tucker (S), Claudio Tuniz (SC), James 3. Ussailis (A), James B. Wanslow (S), Michael J. Wisniowiecki (T)

Student Status

Joseph T. M. Aerssens (S), Suzanne L. Baldwin (T), Walter E. Brown (S), John A. Collins (T), Stephen M. Dickson (O), Joseph O. Ebenird (S), Lynne J. France (T), Adam P. Freedman (T), Donald Hickmott (V), Stephen W. Kline (V), Sukin Lee (O), Stuart Loewenstein (S), Donald Medwedeff (T), Germana Peggion (O), Hamid Rassoul (SA), Ann Marie Semeniuk (P), A. W. Shelton (GP), Tracy J. Stark (S), Scott D. Sihler (S), Roger C. W. Tang (S), Kevin Zahnle (P).

Nominations for 1984 AGU Fellows

Nominations for Fellowship in the Union are being sought by the Fellows Committee and the Section Selection committees. Nominees for Fellowship should be scientists who have attained acknowledged eminence in a branch of geophysics. The total number of Fellows elected each year cannot exceed 0.1% of the total membership.

To be considered by the Committee, nominations for Fellowship in AGU *must be made on the form below*. If more space is needed, attach a separate sheet.

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Name of Nominee ____________ Name of Sponsor ____________

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Education (degrees, institutions, major field) ____________

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Attach a list of most significant publications (not abstracts, book reviews, or papers that have not yet been accepted for publication).

Sponsor's Evaluation of Nominee

Attach a supporting statement which must include: (1) an indication of the length and nature of your acquaintance with the nominee; (2) the nominee's contributions to the field to date; (3) your evaluation of the nominee's scientific ability; (4) a one-line citation, "For ....", summarizing why the nominee should be elected a Fellow.

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Deadline: September 19, 1983

GAP

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Particles and Fields—Magnetosphere

5745 Magnetospheric configuration
SURVEY OF LOW ENERGY PLASMA ELECTRONS IN SATURN'S MAGNETOSPHERE: VOYAGERS 1 AND 2
L. C. Sittler, Jr. (NASA/GSFC, Laboratory for Extraterrestrial Physics, Greenbelt, MD 20771) S. W. Ogilvie and J. D. Scudder

This paper is a survey of the low energy plasma electron environment within Saturn's magnetosphere made by the Plasma Science Experiment (PLS) during the Voyager encounters with Saturn. Over the full energy range of the PLS instrument (10 eV to 6 keV) the electron distribution functions are clearly non-Maxwellian in character; they are composed of a cold (thermal) component with Maxwellian shape and a hot (suprathermal) non-Maxwellian component.

A large scale positive radial gradient in electron temperature is observed, increasing from less than 1 eV in the inner magnetosphere to as high as 800 eV in the outer magnetosphere. This increase in electron temperature explains the observed order of magnitude increase in plasma sheet thickness with increasing radial distance from Saturn. Scale heights of the cold heavy ion plasma can be as small as 0.2 R_S in the inner magnetosphere and as much as 3 R_S in the outer magnetosphere.

Three fundamentally different plasma regimes have been identified from the measurements: (1) the hot outer magnetosphere, (2) the extended plasma sheet, and (3) the inner plasma torus. The hot outer magnetosphere is a region within which the suprathermal electrons are the dominant contributors to the electron pressure, and at times to the electron density. The extended plasma sheet, with mean inner and outer boundaries of 7 and 15 R_S respectively, has enhanced levels of cold plasma relative to that in the hot outer magnetosphere, although the suprathermals continue to dominate the electron pressure. The inner plasma torus is a region of reduced electron temperature (as low as 1 eV), enhanced equatorial densities (as high as 100/cm^3) and reduced scale height (as small as 0.2 R_S). Localized reductions in electron temperature are observed near the L shells of Tethys, Dione, and possibly Rhea. The suprathermal electrons are observed to be severely depleted within the Saturn plasma torus, relative to that in the extended plasma sheet and hot outer magnetosphere. The energy dependence of the depletions indicate an interaction with dust or plasma waves as likely; interactions with neutral gas or plasma ions may also contribute to the depletions. (Plasma electron measurements, cold and hot components, energy dependent depletions, scale height variations).
J. Geophys. Res., Blue, Paper 3A1208

5780 Wave propagation
ION CYCLOTRON WAVES: DIRECT COMPARISON BETWEEN GROUND-BASED MEASUREMENTS AND OBSERVATIONS IN THE SOURCE REGION
S. Perraut (Centre de Recherches en Physique de l'Environnement Terrestre et Planétaire, 92131 Issy-les-Moulineaux, France), R. Gendrin, A. Roux and C. de Villedary

Simultaneous measurements of Ion Cyclotron Waves (ICW's) were performed on GEOS spacecraft and in the vicinity of their magnetic footprints with the French Mobile Station. The detailed comparison between the two sets of data shows that, while ICW's having $F < F_{He}$, the He^+ gyrofrequency at the equator, generally propagate to the ground, only 10 % of those generated above F_{He} can reach the ground station. It is shown that these results are in good agreement with the conclusions that Rauch and Roux (1982) drew on the basis of measurements reported by Young et al. (1981). In an He^+-rich plasma ICW's with $F > F_{He}$ suffer a reflection where the frequency locally matches the local bi-ion hybrid frequency. We extend the calculations of Rauch and Roux and calculate, as a function of the He^+ concentration, the tunnelling of ICW's through the stopband induced by the presence of minor He^+ ions. It is shown that the transmission coefficient strongly depends upon the wave frequency for a given He^+ abundance ratio. The results obtained are shown to be supported by existing observations. (Ion Cyclotron Waves, Pc1, Wave propagation).
J. Geophys. Res., Blue, Paper 3A0745

Geophysical Research Letters

Volume 10 Number 9 September 1983